Study on the presence of perchlorates and chlorates in the SA dairy value chain

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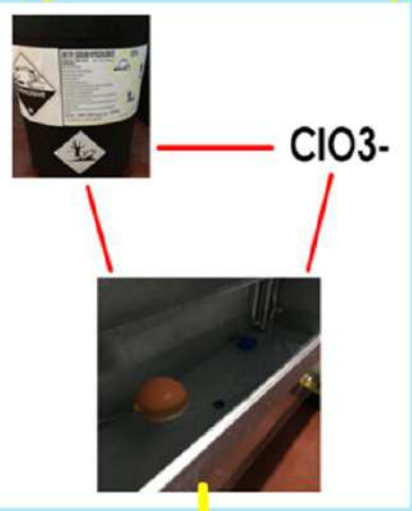
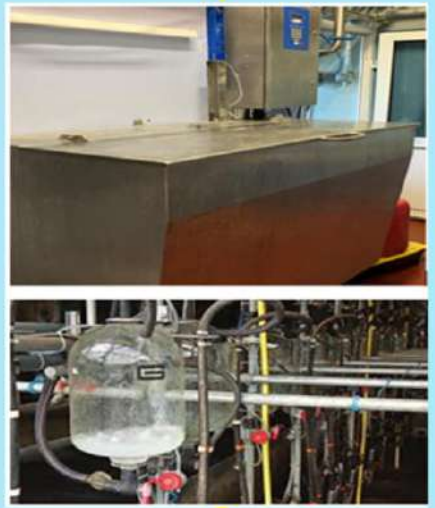
Sodium hypochlorite (chlorine) is a commonly used disinfectant agent for water treatment

Chlorate (ClO3-) is a ubiquitous degradation by-product of chlorine



Therefore, when chlorine is added to water during the treatment process, chlorate is added too

Water is the primary component of any milking equipment cleaning routine



Where chlorinated water is used for this purpose, chlorate will gain access to milk handling equipment

Milk that enters this equipment is at risk of contamination; primarily by adulteration of milk with water containing chlorate

The level of chlorate present in the bulk milk will influence the applications for which this milk can be used at processing level

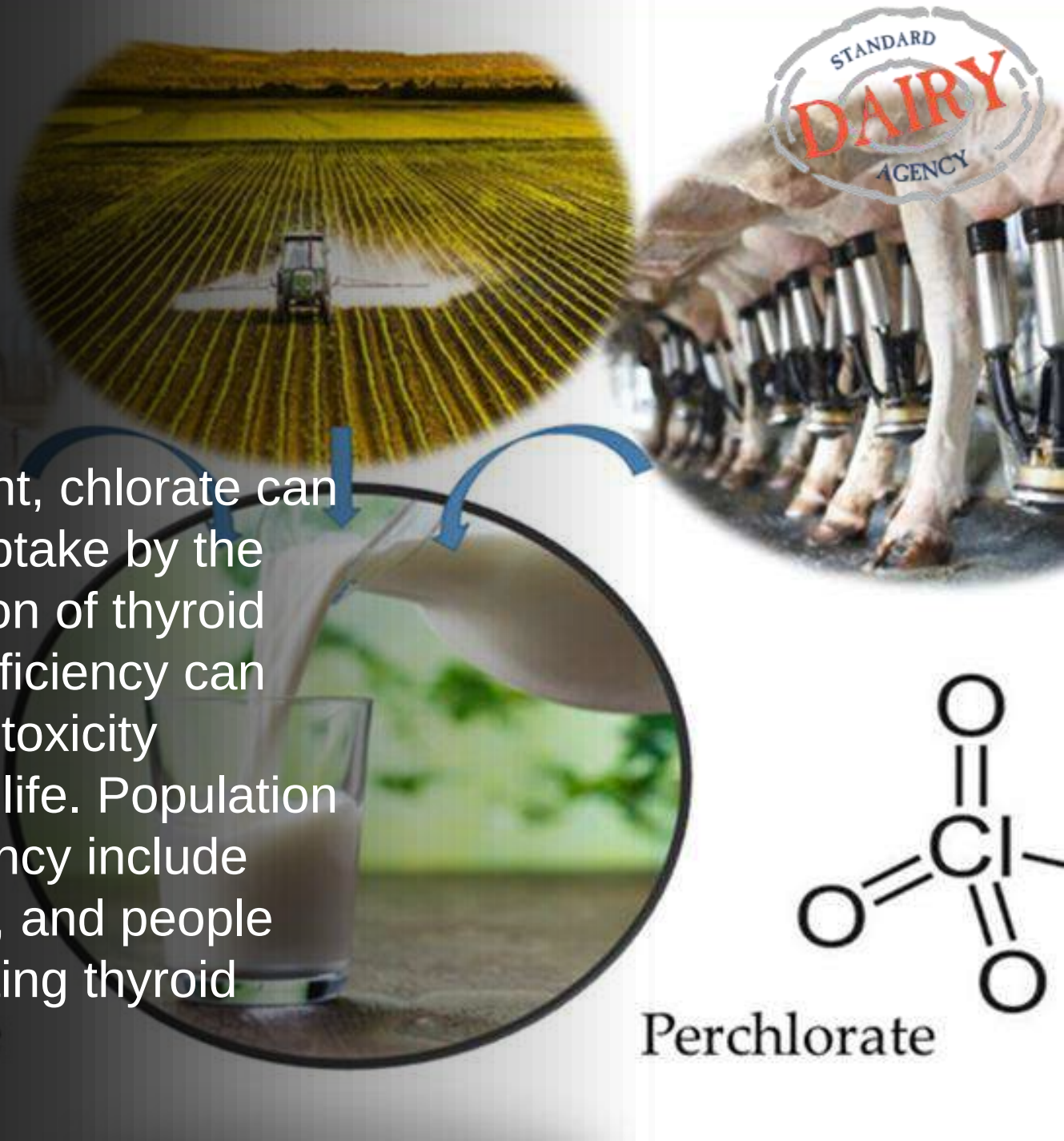
Chlorate

Chlorate (ClO_3^-) is a significant degradation product of chlorine-based disinfectants. It arises largely from chlorine-based products that are widely used in water disinfection processes designed to produce microbiologically-safe potable water.

Chlorate also arises from the use of such products for cleaning and disinfection of milk- and food-contact surfaces along the manufacturing chain from farm to table.

Perchlorate

Perchlorate (ClO_4^-) and, to a lesser extent, chlorate can both have an adverse effect on iodine uptake by the thyroid gland, causing reduced production of thyroid hormones and hypothyroidism iodine deficiency can lead to irreversible neurodevelopmental toxicity (cretinism) at the early stages of human life. Population groups most vulnerable to iodine deficiency include pregnant women, infants, small children, and people with deficient iodine intake or a pre-existing thyroid disease.



Quality management systems within the dairy industry

- As a chemically derived contaminant, chlorate should in principle form part of hazard analysis and critical control point (HACCP) of quality management systems within the dairy industry.
- Chlorate can be further degraded into perchlorate if suitable conditions prevail, and this residue is approximately 10 times more potent than chlorate.
- The EU maximum residue limit (MRL) for perchlorate in foods ranges from 0.01 mg kg^{-1} in infant foods to 0.75 mg kg^{-1} in tea.
- To date, no specific MRL is stated for perchlorate in milk.
- With new EU requirements in place, it is likely that governments and consumers of dairy products will request additional science-based information on possible health risks associated with these residues, consideration of new and current maximum limits, together with recommendations for prevention as well as control and detection methods

Toxicity, exposure and human health risk

- Chlorate has emerged as a residue of concern in the European Union (EU) in recent years due to its threat to human health via its goitrogenic properties and the associated risk to human thyroid function.
- This risk is relevant to all demographics but is of particular importance to those with underdeveloped thyroid metabolisms, i.e., infants and young children.
- Chlorate has been detected in a variety of food groups including dairy products and ingredients such as drinking milk, yoghurt and whey powder.
- Chlorate forms as a consequence of chlorine degradation, which occurs as a function of time, pH, temperature, UV exposure and ionic strength.

Chlorate is a regulated residue in the EU

Chlorate is a regulated residue in the EU in both food and water

The limit on chlorate levels in food is termed a ‘temporary limit’ as it can be updated every five years as new information becomes available.

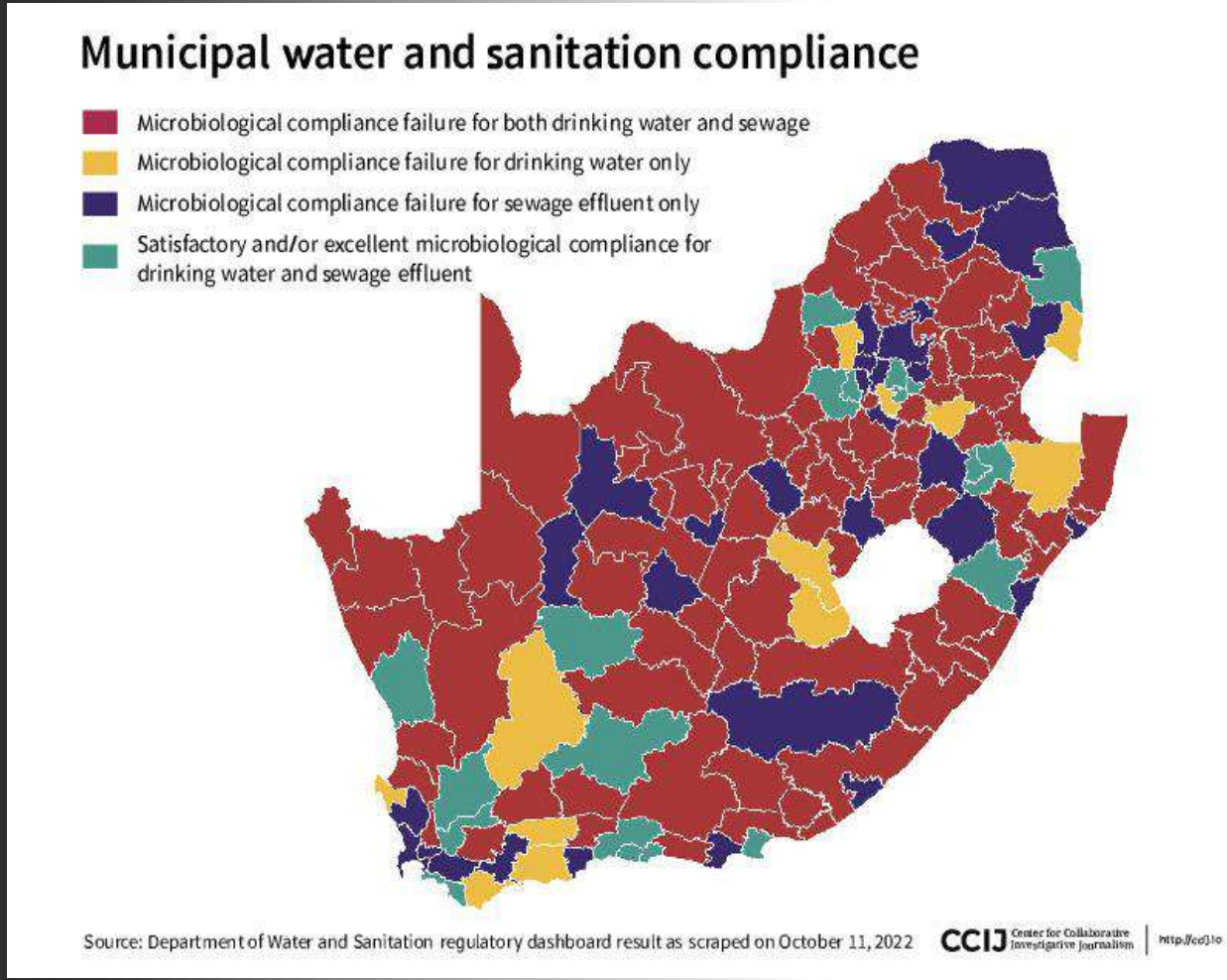
Following the most recent EU accrual of data, the chlorate MRL was amended to more product-specific limits in 2020, from previously generic limit of 0.01 mg kg−1 for all foods

A MRL of 0.10 mg kg−1 has been applied to milk in its ‘ready to use state’ with no further specificity regarding different types of dairy product.

The MRL of 0.10 mg kg−1 for milk is considered the most achievable level based on the ALARA (as low as reasonably achievable) principle without compromising the bacterial quality of milk.

South Africa

Currently South Africa has no legal limits on chlorate levels and a contributing risk is the state of infrastructure and supply of food safe potable water in municipal areas where chlorination practises during water purification are common.



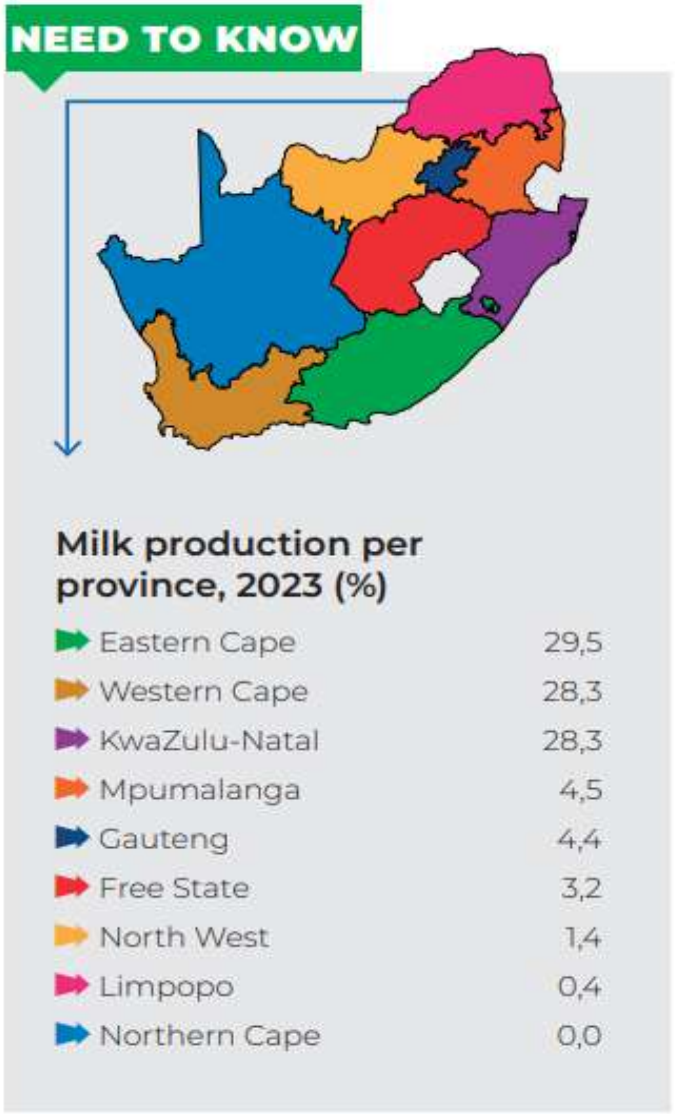
Organised dairy industry's responsibility

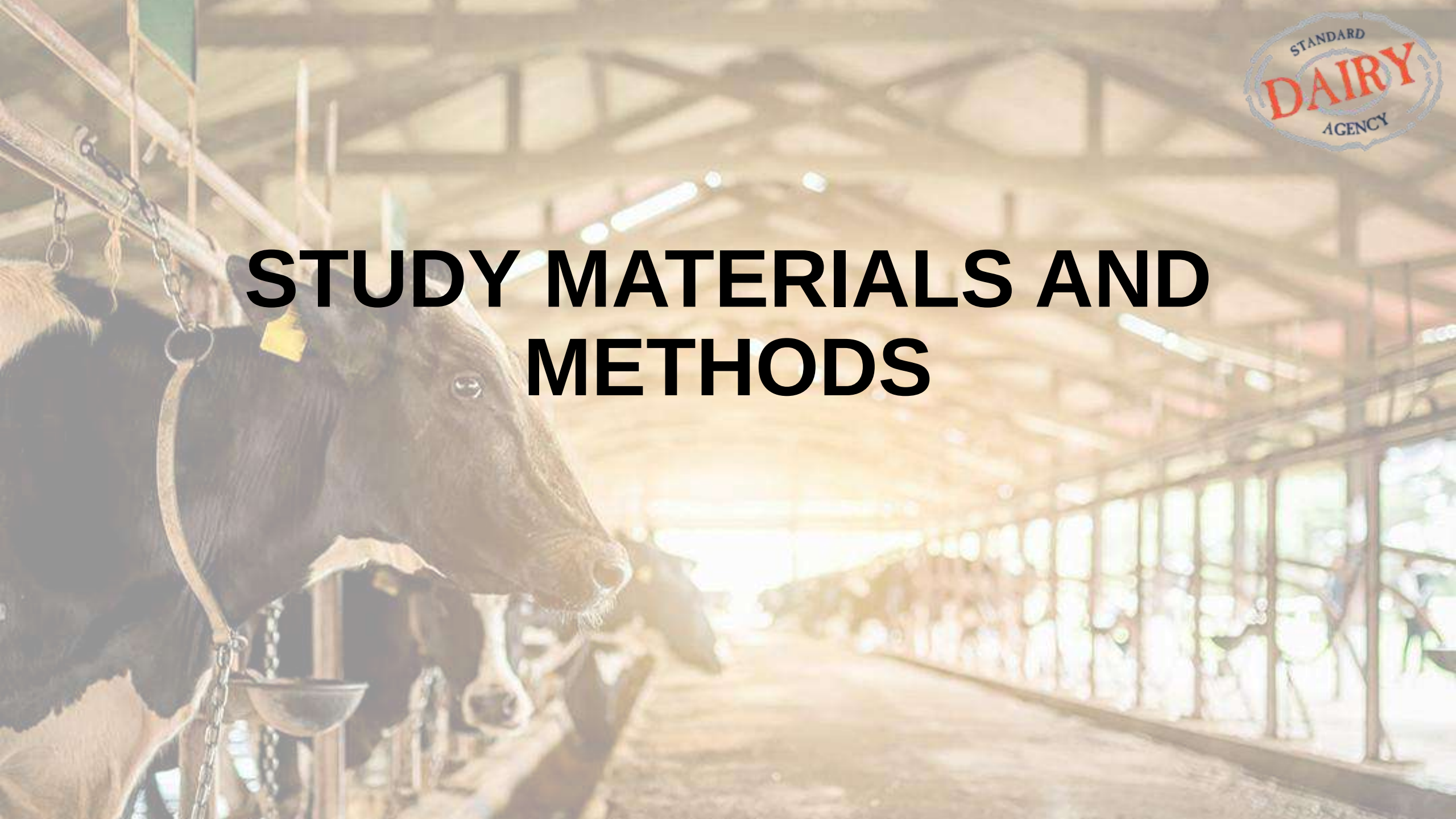
- The organised dairy industry inherently has a responsibility to **protect the value of dairy products** due to the nutritional density and contribution of milk to the dietary intake of consumers in South Africa.
- To this effect risk identification is the first step to take in the strategic action in the **identification and mitigating of potential food safety risks** relating to the presence chlorate.
- This view may also **impact government policy** on the prohibition of chlorine-based chemicals for cleaning and disinfection on farms and in processing plants.
- As raw milk is not routinely tested for chlorates by milk buyers, **little is known about the levels of chlorate present in the indigenous dairy products**, which are staple parts of the daily diets of South African households.
- Therefore, the objective of this investigation is to **establish the levels of chlorate present in pasteurized and unpasteurized milk consumed in South Africa**, over a six-month period.

DATA: INVESTIGATION INTO CHLORATE LEVELS IN DAIRY PRODUCTS PRODUCED AND CONSUMED IN SOUTH AFRICA

Selecting milk for inclusion in the investigation

- South African dairy value chain comprises of approximately **882 dairy producers, 179 dairy processors and producer distributors (PD's), 6 large retail companies as well as regional small to medium enterprises.**
- According to the latest Lacto Data report of June 2024, approximately **3.4 billion kg of unprocessed milk** is annually produced of which more than **1.4 billion liters are sold as fresh, UHT and sterlised milk, representing close to 72% of liquid dairy products** processed and packed in South Africa.
- Further to the above it is estimated that more that **90% of liquid dairy products offered for sale in the South African retail**, originate from the top 20 milk processors at national level.
- Based on volume and the fact that many manufacturers process and pack multiple brands of the same product, **selection of samples was done with care.**
- **Identifying all brands associated with each processor and then targeting the most popular brand from each for sampling (based on market share. Due to the restricted sampling size of 60 samples, only one brand from each processor selected was sampled considering geographical representivity.**





STUDY MATERIALS AND METHODS

Sampling Protocol

- Sampling was conducted during July until December 2024, divided into two sampling periods:
  - *July, August and September – 30 Samples*
  - *October, November and December – 30 Samples*
- During each sampling period, the target is to procure 30 samples of each selected dairy processor, taking into consideration the ‘use by’ dates on retail shelves.
- Samples shall be procured from **six of the most prominent retail outlets nationally as accumulatively, these six retailers have a market share of >90%.**
- Samples were taken according to the relevant sections of ISO 707:2008 Milk and milk products. Where sub-samples are taken from milk, 100 ml sterilised containers provided by the Dairy Standard Agency was used.
- All samples were taken before their ’use by’ dates in order to maximize sample integrity.

Chlorate and perchlorate Analysis

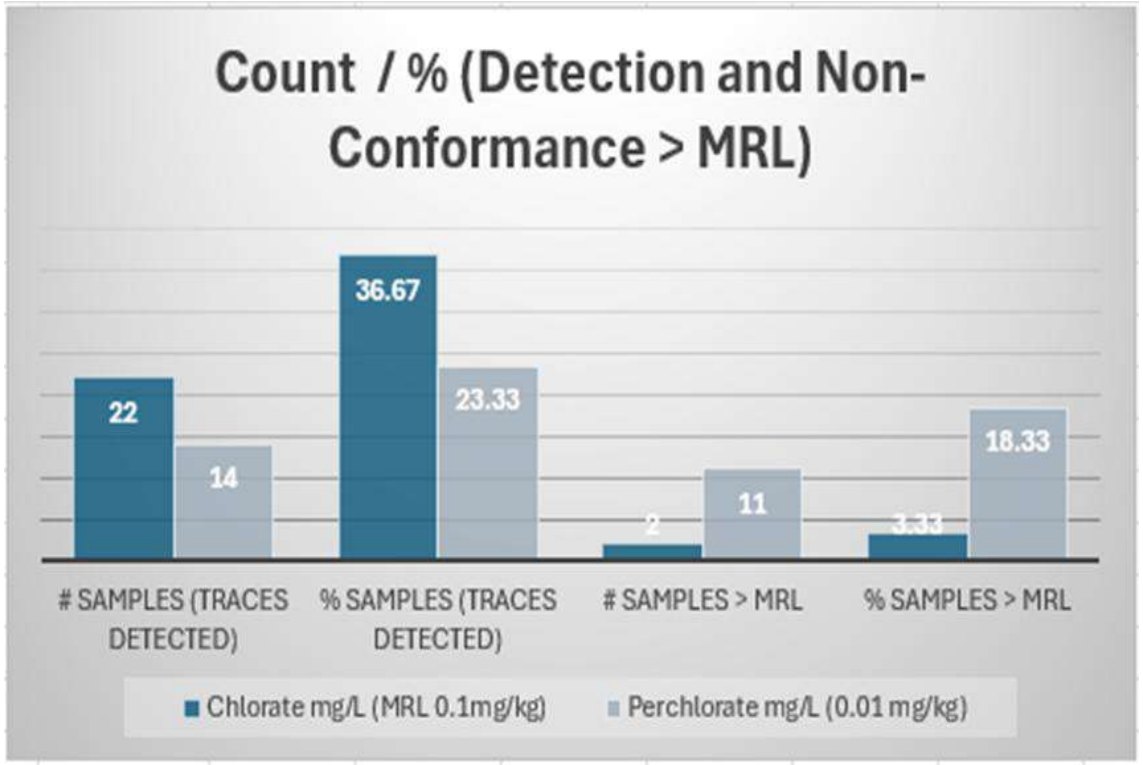
Samples were transported as refrigerated, below 5º Celsius or if required in a frozen state and submitted directly the DSA Lab Services during which full traceability shall be ensured of all samples (processing form) before submission thereof to FDA Laboratory, for chlorate and perchlorate analysis.

This analysis was conducted using ultra-performance liquid chromatography coupled with tandem mass spectrometry (UPLCMS/MS).

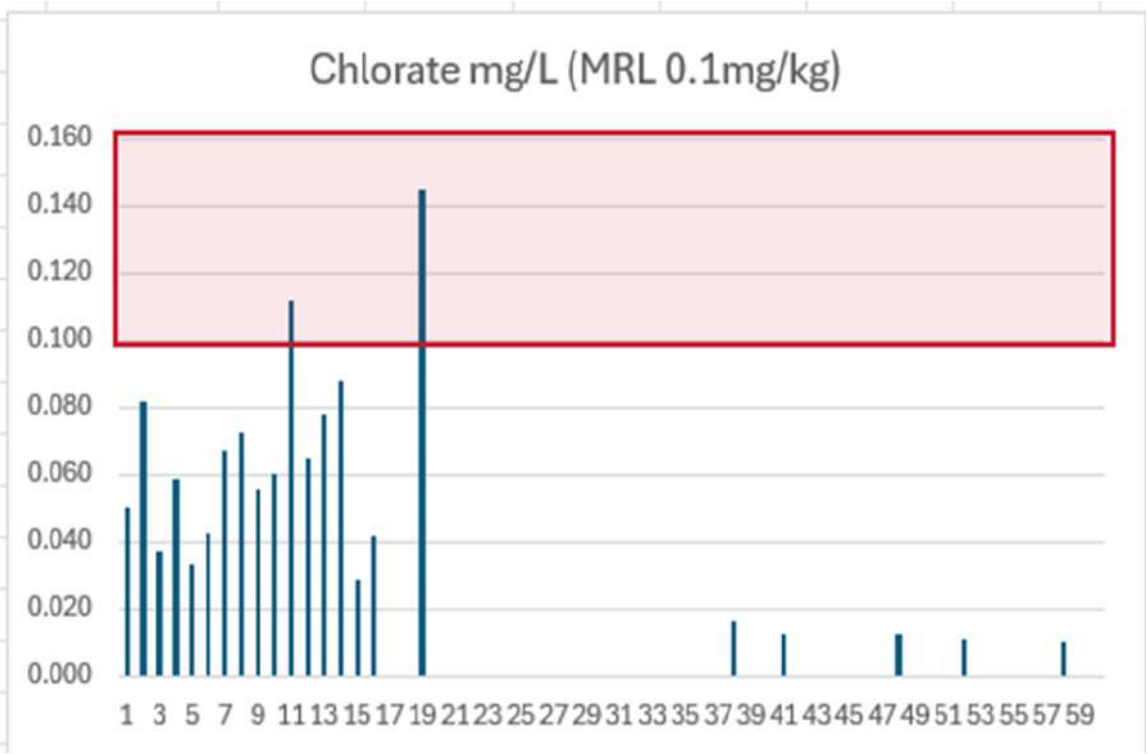
The reporting limit for milk is 0.0020 mg kg^{-1}; where common superscripts are present, the differences are insignificant ($p > 0.05$).

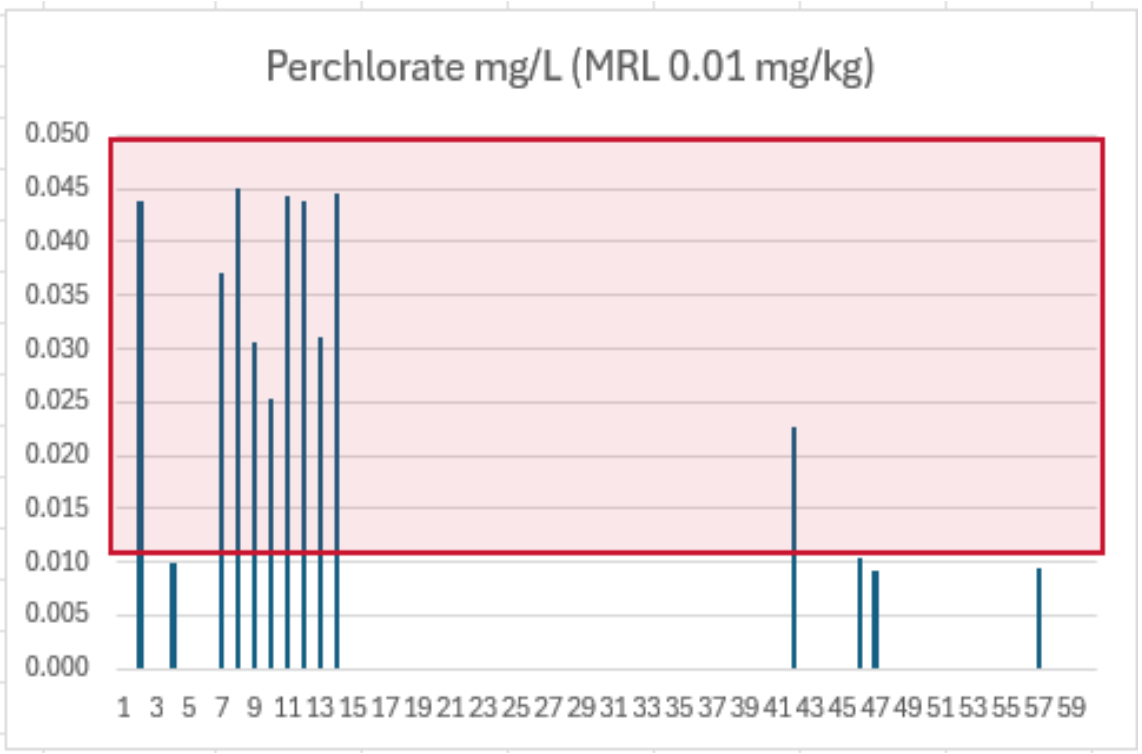
Findings

- In this study, chlorate was detected in 36.67% of the 60 samples tested, with 3.33% exceeding the maximum residue limit (MRL) of 0.1 mg/kg.
- Perchlorate was detected in 23.33% of samples, of which 18.33% exceeded the 0.01 mg/kg MRL.
- These findings suggest the need for a root cause analysis to better understand the primary sources of contamination.



Chlorate & Perchlorate: levels in retail milk sold to public





Conclusion

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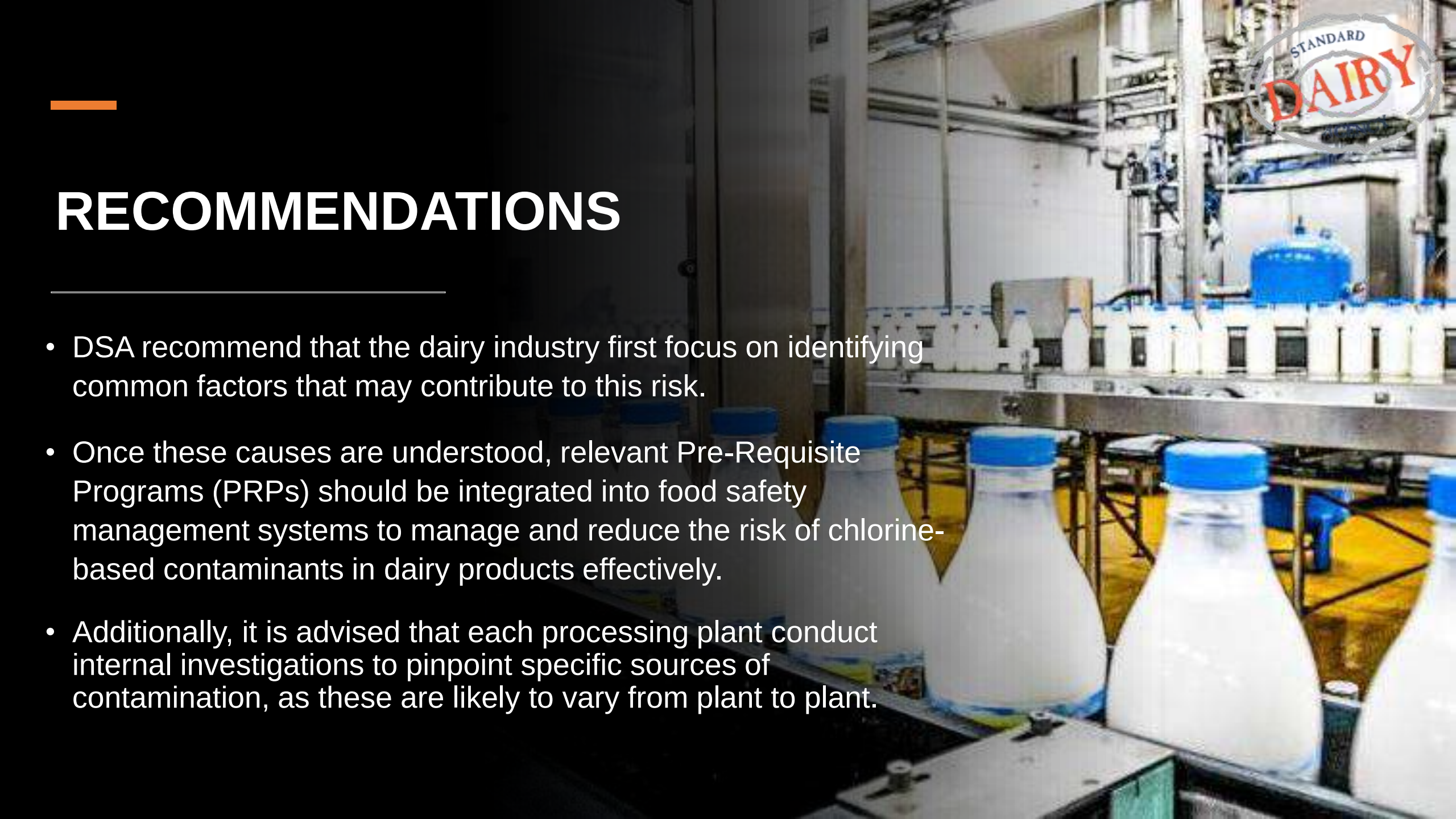
- The presence of chlorate in dairy products is often linked to the use of **chlorine-based detergents for cleaning milk contact surfaces on farms or in processing plants**, as well as the chlorination of processing water (McCarthy et al., 2018).
- **Chlorine disinfection of wash water**, particularly when used in combination with chlorine-based detergents, should also be considered as a potential contributor to the presence of chlorate and related derivatives in dairy products.
- A recurring issue identified in **farm-level Good Agricultural Practices (GAP) audits conducted by the Dairy Standard Agency (DSA)** in South Africa is the lack of routine verification testing when water treatment is applied. This is reflected in the frequent non-conformances reported during these audits.
- At the manufacturing level, the **root cause of chlorine derivative contamination remains uncertain.**

RECOMMENDATIONS

- DSA recommend that the dairy industry first focus on identifying common factors that may contribute to this risk.
- Once these causes are understood, relevant Pre-Requisite Programs (PRPs) should be integrated into food safety management systems to manage and reduce the risk of chlorine-based contaminants in dairy products effectively.
- Additionally, it is advised that each processing plant conduct internal investigations to pinpoint specific sources of contamination, as these are likely to vary from plant to plant.



References:

IDF Fact Sheet No 28/2023

Chlorate levels in Dairy Products Produced and Consumed in Ireland: Foods, 2023 June 30

Thank you/Dankie

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